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Energy calibration of Cherenkov Telescopes using GLAST data

D. Bastieri[1], G. Busetto[1], A. De Angelis[3], F. Longo[2], G. Piano[1], R. Rando[1] and A. Saggion[1]

[1]Università di Padova & INFN Padova, Via Marzolo 8, I-35131 Padova, Italy
[2]Università di Trieste & INFN Trieste, Via F. Valerio 2, I-34127 Trieste, Italy
[3]Università di Udine & INFN Trieste, Via delle Scienze, 208 - I-33100 Udine, Italy

Abstract We discuss the possibility of using the observations by GLAST of steady gamma sources, as the Crab Nebula and some selected AGNs, to calibrate the Imaging Air Cherenkov Telescopes (IACT) and improve their energy resolution. in particular. We show that at around 100 GeV, exploiting the features in the spectrum of the Crab Nebula, the absolute energy calibration uncertainty of Cherenkov telescopes can be reduced to <10%.

Full multiwavelength coverage over as wide an energy range as possible is needed to understand aspects of fundamental physics and astrophysics as well. An important observational window, between ~10 and ~100 GeV, is still largely unknown due to experimental detection difficulties, related to the opacity of our atmosphere to γ-rays. For this reason, observations have to be performed:

- on board of satellites orbiting outside the atmosphere (where the limited size of the detectors sets an upper limit of the sensitivity),
- detecting, on the ground, showers initiated by gamma-rays in the atmosphere (in this case, there is a lower limit of the sensitivity).

Among ground-based detectors, IACTs are expected to reach the lowest energy thresholds. On the one hand, IACTs feature huge collection areas, an excellent angular resolution and a good energy confinement. On the other hand, they suffer from a low duty-cycle, small fields of view (<5°) and systematic calibration uncertainties in both energy and sensitivity. In fact, whereas IACTs have an intrinsic energy resolution as low as ~5%, the absolute energy scale remains quite elusive, as the energy reconstruction in the 30÷300 GeV range is dominated by uncertainties on Monte Carlo simulations and the atmospheric model.

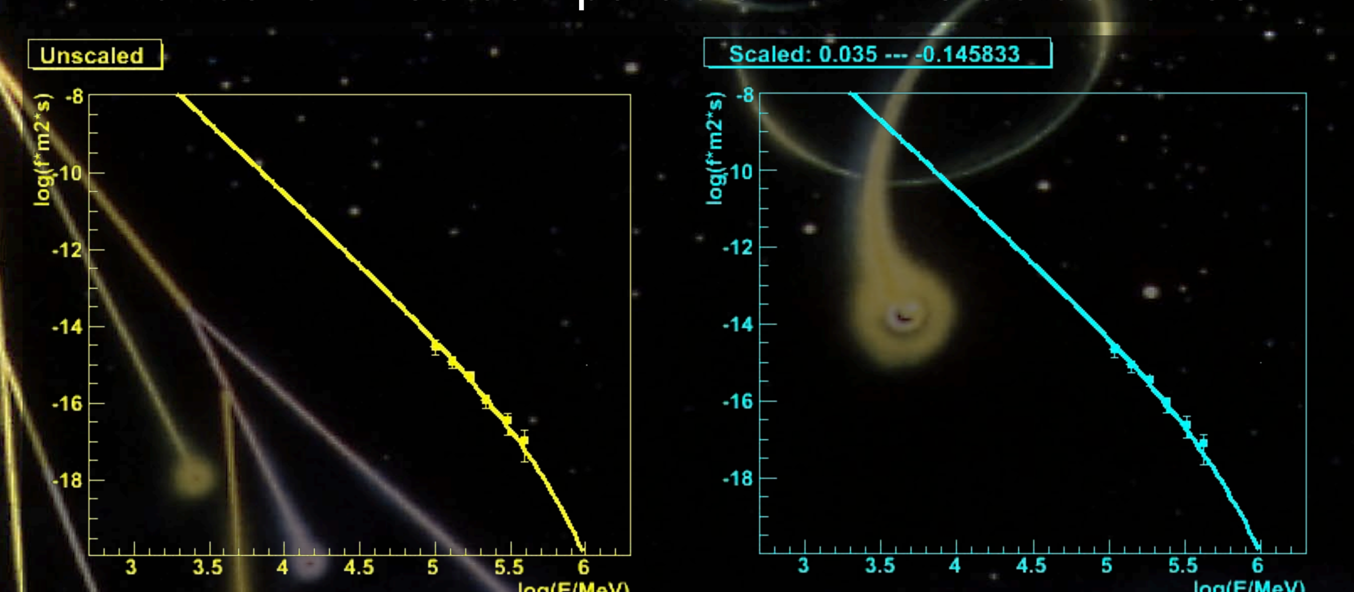
GLAST, contrarily to IACT, is calibrated in a well-controlled laboratory environment, using test beams of electrons and γ-rays, and a relative uncertainty of ~10% or better is expected. After GLAST launch, while LIDARs can provide IACTs with regular measurements of atmospheric transmission, GLAST observations of higher energies sources can be used to reduce systematic errors in the absolute energy scale determination of IACT events [1].

Calibrating with the CRAB Nebula and the AGNs

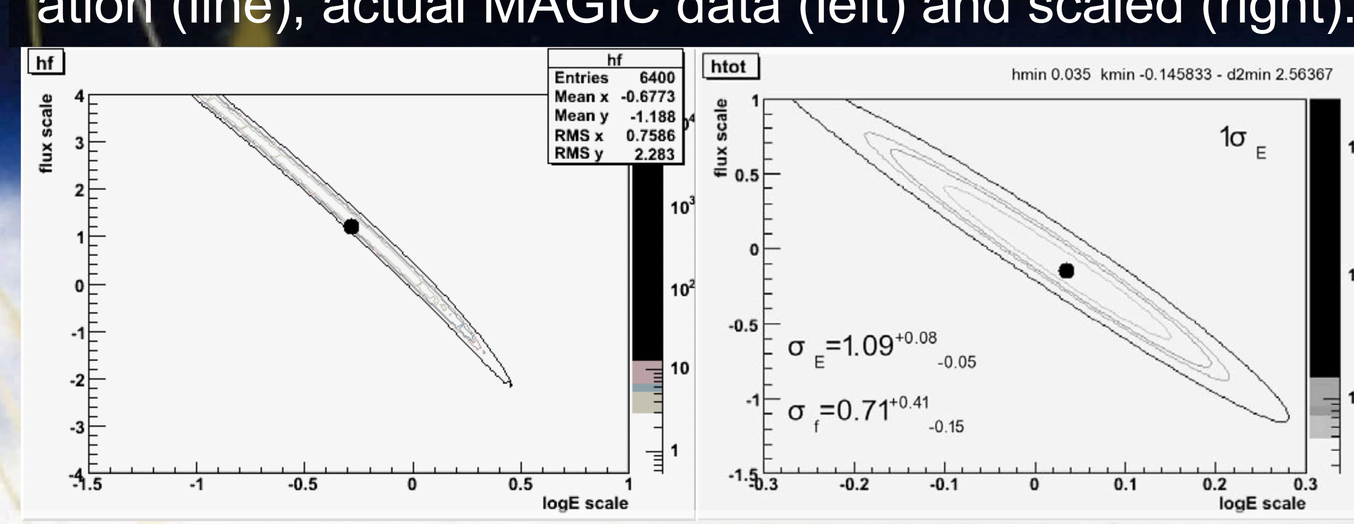
The spectrum of the **Crab Nebula** is expected to change substantially around 100 GeV. It can be parameterised as a two-slope spectrum with indexes 2.0 for $E < E_{brk}$, and 2.7 for $E > E_{brk}$, where E_{brk}~100 GeV. **The position of this spectral break, well determined by GLAST, can be used to calibrate the IACTs.** The number of photons collected in the first year by GLAST between 10 and 300 GeV (survey mode, ×90% data efficiency), obtained simulating for different E_{brk} the Crab spectrum, is listed in the table under the header ***Crab***. E_{brk} was then fitted assuming the actual energy resolution of GLAST (see column ***GLAST***). As far as IACTs are concerned, we used the Crab data provided by MAGIC at energies above 100 GeV [2]. The column headed ***IACT*** refers to the **total** scale uncertainty of MAGIC and is the sum in quadrature of the **absolute** scale uncertainty (~30%) and the **intrinsic** one, whereas the last column refers to the **total** scale uncertainty of MAGIC when using GLAST information on the position of E_{brk}.

E_{brk}	# phot	GLAST	IACT	GLAST+IACT
50 GeV	3763	6.2%	40%	26%
100 GeV	3249	8.2%	37%	22%
150 GeV	2988	13%	35%	22%
200 GeV	2818	17%	34%	24%

Beside the Crab, many other sources, typically AGNs, do show a featured spectrum. Their power-law spectrum is in fact folded with an exponential cutoff due to the absorption by the Metagalactic Radiation Field. The position of this cutoff, if reconstructed both by GLAST and IACTs, can be used to reduce the absolute scale uncertainty as in the case of Crab Nebula data. But they can also help in reducing other possible systematic misbehaviors: there can be in fact some scaling error in reconstructing the fluxes or the energies. For this purpose we used the data collected on 3EG J1608+1055 (PG 1553+113 [3]) and 3EG J1222+2841 (1ES 1218+304 [4]). We compare the GLAST simulation with the data obtained by IACTs and infer the two scale factors that should affect flux and energy. As can be seen from the graphs below, even two AGNs are able to constrain these factors with uncertainties comparable with the actual ones.



Spectrum of PG 1553+113 as seen by GLAST simulation (line), actual MAGIC data (left) and scaled (right).



Constraints on scale factors as set by PG 1553+113 alone (left) and together with 1ES 1218+30.4 (right).

CONCLUSIONS

We showed how we can reduce the uncertainties in the spectrum reconstructed by the IACTs. This approach was proven to be comparable with the current estimates of the systematic errors affecting the measurements. As the GLAST catalogue will embrace more and more sources, these errors will get smaller allowing us to observe the sky at very high energies with unprecedented precision.

REFERENCES

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